DEPARTMENT OF AGRICULTURE.
BOTANICAL DIVISION.
BULLETIN NO. 7.
SECTION OF VEGETABLE PATHOLOGY.

BLACK ROT

(LÆSTADIA BIDWELLII).

BY

F. LAMSON SCRIBNER,
CHIEF OF THE SECTION OF VEGETABLE PATHOLOGY,

AND

PIERRE VIALA,
PROFESSOR OF VITICULTURE IN THE NATIONAL SCHOOL OF AGRICULTURE AT MONTPELLIER, FRANCE.

WASHINGTON:
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BLACK ROT OF THE GRAPE.

(From an original photograph.)

LETTER OF SUBMITTAL.

SIR: I herewith submit for your approval a report on Black Rot of grapes, embodying the results of observations made under your direction in 1887, and the conclusions thus far obtained the present season in combating the disease.

Very respectfully,

F. LAMSON SCRIBNER.
Chief of the Section of Vegetable Pathology.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

INTRODUCTION.

In various reports of the Department, especially in Bulletin 2 of the Botanical Division, also in reports of horticultural societies and in the public press, I have described more or less fully the characters of Black Rot and the nature and extent of the losses this disease has occasioned to American viticulture. During the summer of 1885 Black Rot was discovered in France for the first time, and was at once made the subject of most careful study by the eminent viticulturist, Prof. P. Viala, of the National School of Agriculture at Montpellier, and his able assistant, M. L. Ravaz. The first elaborate and well-illustrated account of the disease was the result of the studies then made by these gentlemen.* The first paper illustrating the perfect or ascosporous form of the Black Rot fungus was prepared by myself and published in the Botanical Gazette for November, 1886.† The special investigations on this subject which have been continued by Messrs. Viala and Ravaz and by M. Prillieux have been published from time to time in French reports and scientific journals.

Early in the summer of 1887 Professor Viala was commissioned by his Government to visit this country in the interests of French viticulture. He reached Philadelphia June 9, where, by the direction of the Commissioner of Agriculture, I met him, and from that time until his departure for France, early in the following December, we were, with the exception of a few days, constantly together. As our work was largely in the same line and of mutual interest, the Commissioner directed that I join him in his field excursions, and place at his disposal such facilities for investigations as our mycological laboratory afforded. Together we visited vineyards in New Jersey, Maryland, Virginia, North Carolina, New York, Ohio, Texas, and California. Professor Viala also visited the States of Tennessee and Missouri, but as I was unable to accompany him at this time I did not participate in his interesting discoveries of *Pourridie* and of *White Rot*‡ made in Missouri. I would state, however, that at the moment of these discoveries Professor

* Viala and Ravaz: "*Le Black Rot*," Montpellier, 1886.

† Scribner: "*Botanical characters of the Black Rot, Physalospora Bidwellii*," Bot. Gaz., Vol. XI, p. 297, with one plate.

‡ For an account of this disease see Ann. Rept. Dept. Agr. 1887, p. 325.

Viala telegraphed the facts to me and, with his usual generosity, announced that they should be considered as having been made jointly.*

The wide extent of country covered by these field observations enabled us to note the range of the several diseases of the vine, and to study them under most varying circumstances. Many new and interesting facts were discovered and important questions solved. Pourridie and White Rot were recognized in this country for the first time, and a new disease affecting the berries, named Bitter Rot,† was discovered.

The results of the observations made on Black Rot are embodied in this report which has already been presented to French readers by Professor Viala under the title of "*Le Black Rot en Amérique.*" In rendering the report into English I have taken some liberties which appeared to be justifiable under the circumstances, and some observations of interest only to French readers have been omitted. The successful results of experiments made in treating Black Rot the past season will add special interest to the chapter on treatment and render the report more complete.

* On September 22 of the present year I found White Rot in the vineyard of the Department grounds on the berries of a single vine, a white variety named Alma.

† See Ann. Rept. Dept. Agr. 1887, p. 324.

BLACK ROT OF GRAPES.

I.—Distribution.

Black Rot occurs throughout the States east of the Rocky Mountains on all wild and cultivated vines. California has not yet been invaded by the disease; it is one of the few States which is as yet exempt from this terrible scourge. This immunity from Black Rot is due to several causes. The climate is very different from that of the Eastern States and important physical characters completely isolate it from the latter. The Rocky Mountains form an important barrier from North to South, and to this is added on the one side the Sierras with a nearly parallel course, and on the other side, extending in the same direction, the nearly continuous heated and arid areas which form the deserts of Colorado, Mojave, and Nevada. The transportation of fungi by drying winds across these vast regions is impossible. Furthermore, the climate of California is comparatively dry, especially in the southern vineyards, and this, together with the fact that importations of cuttings from the East has only recently been carried on, sufficiently explains why the diseases common to the Atlantic coast have not yet invaded that State. It is certain, however, that sooner or later Black Rot will invade the northern vineyards of California, where the climatic conditions of certain sections are favorable to the development of parasitic fungi; this is especially true in the region about San Francisco, including the vine-growing counties of Napa and Sonoma.

In New Mexico and Arizona, where summer rains are infrequent, Black Rot has not been observed, nor has it been seen in Colorado and Utah, where there are few wild vines and where vineyards, properly speaking, do not exist. But Black Rot is to be found everywhere else, even in Canada in the provinces of Quebec, Ontario, and Manitoba. It is especially frequent and destructive in the States bordering the Atlantic, the Great Lakes, and the Gulf of Mexico, where there is much moisture and a high summer temperature; it is the same along the banks of large rivers, notably in the States of Missouri and Ohio.

Its virulence lessens as the humidity diminishes, for there is sufficient heat in all the States at the time when the fungus develops most actively. Thus in Texas its ravages are unimportant, excepting in the north along the banks of the Red River, and in the center along the

Brazos and Colorado; in western Texas, where it is very dry, the disease has not been observed. This is the case, for example, at El Paso, which forms its southwestern limit.

Black Rot attacks not only cultivated vines, but also different species of wild grapes in forests far removed from cultivated vineyards. We know of no wild species of the eastern or central States which may not be attacked by it. We have observed it on the banks of the Niagara on leaves of *Vitis riparia* and of *Ampelopsis quinquefolia*, and again in the forests of Maryland and New Jersey, where we saw the wild *Vitis labrusca* with its leaves covered with spots and its fruit destroyed by the parasite. In Indian Territory, in the dense virgin forest, the leaves of the young shoots of *Vitis cordifolia* were seen covered with the pustulate spots of Black Rot. We have even observed it, but in rare cases, upon leaves of *Vitis monticola* in the dry parts of Texas where this species occurs. The Mustang and Lincecumii, growing along the banks of the Red River, were also seen to bear the pustules of the disease. *Vitis rupestris*, which grows in dry ravines, is the only species which does not have its leaves spotted with Black Rot, but this does not prove that in other localities or in other soils the fungus would not attack it.

II.—Severity.

Black Rot is the most serious and important disease of the vine in the United States. In America only can one appreciate the full extent of the ravages of this malady. There is no disease of the vine yet known that causes in a few days such great losses, and our viticulturists rightly consider Black Rot as the worst of all scourges. After numerous trials the culture of European vines has been abandoned even in sandy soils where they would be resistant to Phylloxera; in the northern regions this is partly because of the low temperature, however, but it is more especially on account of the Black Rot; and in consequence the varieties of *Vitis labrusca* have been multiplied in spite of their inferior value.

The numerous varieties of vines which have been originated and which are still being multiplied in the United States, have been propagated with the hope of discovering one which would be proof against Black Rot. The crossing of American varieties with French vines has been wholly abandoned, for it has only resulted in disappointment; all vines crossed with *Vitis vinifera* regularly lose their crop if the climatic conditions are at all favorable to the parasite. At present viticulturists resort to the hybridization of those species only which they consider most resistant to the Black Rot, such as *V. Lincecumii* and *V. rupestris*. In the Carolinas, Georgia, Alabama, Mississippi, and Louisiana varieties of *Vitis rotundifolia* are cultivated, especially Scuppernong, Flowers, Tender Pulp, Thomas, etc., because in these States it is impossible to save the product even on the most resistant varieties of *Vitis labrusca;* this is the only reason for retaining, in these warm and humid regions, varieties which yield wines of little value.

Mildew is less common and causes less loss to the crop, although in consequence of repeated attacks during several years it may cause the death of the vine. This never results from Black Rot.

In Vineland, N. J., Seabrook, Md., Charlottesville, Va., the vicinity about Saint Louis and Neosho, Mo., and at Dallas, Texas, the majority of the vines lost, in 1887, 80, 90, and 95 per cent. of their crop by Black Rot. In June we visited a warm, humid portion of Maryland, The berries at that time were no larger than small peas, yet two-thirds had already been ruined by the Rot. Vine-growers have everywhere assured us that in the years most favorable to the development of the disease not a berry escaped.

In Tennessee, near Nashville, upon the banks of the Cumberland· Mr. M. O. Randall obtained, in 1885, 4 hectoliters (88 gallons) of wine from a hectare (2½ acres) of young vines; in 1887, owing to Black Rot, the product from the same vines was only 4 litres (about 1 gallon).

* * * There are some historical failures in the culture of the vine which may be mentioned here. The failure of Lakanal, obtained by the culture of European vines in Ohio, Kentucky, and Alabama, or those of the Swiss vineyards of Nouvelle-Vevey, in Ohio, were without doubt as much due to Black Rot as to the severe cold of winter.

At the time when Longworth undertook to cultivate vines on a large scale about Cincinnati the Catawba had just been originated and there were strong hopes that this variety would be resistant to Black Rot. According to the advice and example of this distinguished viticulturist large areas were planted, but Black Rot successively ruined all these vineyards. New plantings were made in the same vicinity when the Ives Seedling came into notice, but the immunity of this vine, which had been tested for several years, was not maintained, and the planting of vineyards was again arrested. Facts of the same kind might be reported for Illinois, Virginia, New Jersey, and Maryland; in the last three States vine-growers have given up grape culture where moisture is most abundant during summer. In years of severe attack it has not been possible to save grapes for the table unless the precaution was taken to cover them with paper sacks.

At the time when the Rogers hybrids (*Labruscav* × *inifera*) were introduced, a company with a capital of $200,000 was organized in Missouri for the cultivation of the vine. Very large tracts of land were purchased at a low price and distributed among vineyardists who sold their produce to the company. Roger's hybrids had given two good crops and the hope of realizing large profits imparted confidence in the success of the interprise. But Black Rot very soon ruined all the products, and brought disaster to the vine-growers and to the company, in spite of the zeal and knowledge of the viticulturist who directed it.

Messrs. Bush & Son purchased the place which is now the town of Bushberg from a vine-grower who had lost his entire property in grape culture. Black Rot destroyed the greater part of his crop every year.

Messrs. Bush & Son have never planted large vineyards themselves on account of this disease; they consider that when Black Rot destroys only 25 per cent. of the crop it is a good year, and they do not consider vine culture necessary to their more important nurseries.

At Denison, in northern Texas, the Italian colonists attempted to cultivate their native vines, but they were soon obliged to dig them up and replace them by Concords. It was the same at Dallas, where Cantagrel established a French colony of Fourrieristes who attempted the culture of French vines, but abandoned them for the same reasons.

III.—Varieties attacked—Degrees of susceptibility.

All that we have said goes to prove that European vines are more subject to Black Rot than American. It is not necessary to repeat here that all hybrids of *V. vinifera* are very susceptible to the disease. It has been stated above that we have observed Black Rot on the wild varieties in the forests from the Northern States as far south as Texas; e. g., *Vitis labrusca*, *V. riparia*, *V. cordifolia*, *V. æstivalis*, *Ampelopsis quinquefolia*, *A. bipinnata*, *Vitis Arizonica*, *V. Californica*, *V. Novo-Mexicana, and V. rotundifolia.* The young leaves of *Vitis Arizonica* and *V. Californica*, growing at Denison, had their foliage spattered with spots of Black Rot in some cases, but it is especially *V. labrusca* which in its wild state has its leaves and fruit destroyed by the disease. *Vitis rupestris*, *V. berlandieri*, *V. cinerea*, *V. Lincecumii*, *V. monticola*, and *V. candicans* occasionally have a few disease spots on their leaves, but never on their fruit. Black Rot is seen but rarely on the fruit *Vitis riparia*, *V. Novo-Mexicana*, *V. cordifolia*,* and *V. rotundifolia.*

Among the varieties which have been cultivated in the United States Othello, Triumph, Brant, Canada, Black Defiance, and Secretary can not be utilized on account of Black Rot. Othello and Secretary have been discarded and are now found only in nursery collections. Messrs. Bush & Son & Meissner have a few stocks of Secretary ten years old which have never fruited, Black Rot having each year destroyed the crop. Prentiss, Bacchus, Pocklington, and Peabody lose all their harvest some years; the same is true of the Roger's Hybrids, Rickett, Niagara, and Catawba.

When the season is unfavorable to the disease various degrees of resistance to Black Rot appear in the different varieties. The Elvira, Concord, and Ives Seedling are less susceptible than those named above; the same may be said of Neosho, Iron Clad, Jaeger's No. 100, Perkins, and Missouri Riesling; the Iron Clad, which is said to be very resistant, is far from having perfect immunity.† As we have already stated in

*This year (1888) I received from Mr. Hermann Jaeger, of Neosho, Mo., clusters of *Vitis cordifolia*, with the berries literally covered with the pustules of Black Rot.—F. L. S.

†In the vineyard of Alex. W. Pearson, who originated the Iron Clad, this variety was entirely free from Black Rot in 1888, while the fruit of the Concord and of other varieties growing with it was completely destroyed by the disease.—F. L. S.

previous publications, varieties with large, juicy berries are the ones most subject to Black Rot, a fact confirmed by our recent observations. It appears also that the later the berries are in ripening the less effect Black Rot has upon them; perhaps the relative resistance of the cultivated varieties of Æstivalis is due to these two facts. Cynthiana, or Norton's Virginia, is least subject to Black Rot of all American varieties, and on account of this fact viticulture is economically possible in certain parts of Virginia, southern Missouri, and northern Texas. This variety, however, loses much fruit during those years when the summer is very moist; thus in Virginia it lost two-fifths of its crop in 1887; but at the same time the fruit of all other varieties was almost wholly destroyed. The Herbemont is nearly as resistant as the Cynthiana, and on this account these two varieties are most widely cultivated in the south. The Jacquez is less resistant, and its culture has been abandoned in southern Missouri and in the vicinity of Dallas and New Braunfels, Tex., chiefly on this account. Varieties of *Vitis rotundifolia* (Scuppernong, Thomas, etc.) are the only vines whose fruit is never destroyed by the disease.

IV.—Conditions favoring development.

At all points in the United States where the ravages of Black Rot are most severe the summers are very warm and moist; this is the case especially in New Jersey, Maryland, Virginia, and the Carolinas. Next to Bitter Rot, Black Rot is a disease that demands in the greatest degree these two climatic conditions, warmth and moisture, for its development. * * * That the losses are so frequent and important is due to the fact that in the majority of the States east of the Rocky Mountains, and especially along the borders of the Atlantic, the months of June, July and August are moist and very warm. We have already said that in southwest Texas, in California, Arizona, etc., where the summers are warm and dry, Black Rot does not exist. In the Central and Northern States, when the seasons are dry, little injury is done. The year 1887, during which rains were infrequent in those States, afforded ample proof of this.

In western New York, at Hammondsport, there are quite large vineyards upon the hillsides surrounding Lake Keuka; at this point, in consequence of the altitude and exposure, dews and mists are rare and Black Rot causes but little damage; the losses, however, sometimes reach 10 per cent. In 1887 only traces of the disease were found, and in the parts most exposed the loss did not exceed 1 per cent.

In the islands of Lake Erie (Kelley's Island, Middle Bass, etc.) in wet years the losses reached 75 and 80 per cent. of the crop; in 1887 it was necessary to search in order to find any berries showing the effects of Black Rot; at Sandusky, on the shore of Lake Erie, where Black Rot frequently destroys 80 per cent. of the fruit, the loss in 1887 was only

4 or 5 per cent.;* the same was true at Fredonia, Dunkirk, and Brocton, in New York, and in all these places the absence of dews or fogs during this year was marked.

The same differences in the degrees of severity of the disease as compared with the humidity of the atmosphere, and especially with the presence or absence of dew and fogs, have been noted in the Central States and in the South. In Tennessee grape culture is really not remunerative excepting above the limit of fogs. Thus upon the plateaus of the Cumberland there is a Swiss colony that cultivates the vine successfully, and upon the lower hills of Ashland County, Ives Seedling gives moderately good crops, although Black Rot is more frequent; but upon the Cumberland River, where thick morning fogs are frequent and where the temperature is high, vine products amount to almost nothing. At Bushberg, Mo., the injury in 1887 was not more than 25 per cent., on account of the drought, but it frequently amounts to 100 per cent.

In Texas, at Lampasas, Austin, and Belton, where drought is the general rule, only traces of Black Rot were observed in 1887; more to the south, however, at New Braunfels, on the Guadalupe, the culture of Jacquez is almost impossible on account of dews which favor the disease.

At Charlottesville, Va., in 1887, drizzling rains and dews were frequent and the injury amounted to 80 to 100 per cent., according to the variety. The same was true in southwestern Missouri. The following meteorological observations, kindly furnished by Hermann Jaeger, of Neosho, by whom they were taken, give exactly the degree of temperature and the frequency of dew, rain, and fog in the latter place, where the injury from Black Rot was very severe in 1887. It seems useless to discuss these data; they are sufficiently conclusive in themselves.

Record of temperature, rainfall, dew, etc., from June 5 to October 25.

Date.	Temperature.			Rain.	Dew.	Fog.
	6 a. m.	1 p. m.	6 p. m.			
1887.						
June 5	55	93	83		Very heavy	Some.
6	58	92	33		Heavy	
7	70	90	84		Medium	
8	72	90	85		do	
9	73	92	84	2 showers, 0.1 inch	do	
10	70	94	83	2 showers, 0.2 inch	Heavy	
11	73	80	78	2 showers, 0.4 inch	do	
12	75	97	75	1 rain, 1 inch	do	Some.
13	74	88	83		do	Trace.
14	62	90	84		do	
15	64	90	85		do	
16	66	89	85		do	
17	70	92	86		Light	
18	68	96	93		Heavy	
19	76	96	94		Medium	
20	74	97	92		Light	
21	62	85	83	1 rain, 0.1 inch	do	
22	64	82	80		Heavy	

* In 1888 the season in this region was very moist and the loss from rot amounted to fully one-third of the crop; this loss, however, was due to Brown Rot caused by *Peronospora*, and not to the fungus of Black Rot, although the latter was present to some extent.

Record of temperature, rainfall, dew, etc., from June 5 to October 25—Continued.

Date.	Temperature.			Rain.	Dew.	Fog.
	6 a. m.	1 p. m.	6 p. m.			
1887.						
June 23	62	82	79		Heavy	
24	62	78	75	Several, 1.4 inches		
25	64	78	76	All night, 3 inches		
26	70	88	82		Heavy	
27	68	84	80		do	
28	70	88	72	Sprinkle,		
29	73	81	80	Sprinkle, 0.3 inch	do	
30	70	80	78	Sprinkle,		
July 1	72	80	76	Several, 0.5 inch	do	
2	70	82	80	1 sprinkle	do	
3	72	89	88		do	
4	75	92	78	2 rains, 0.2 inch	do	
5	78	94	72	2 rains, 2 inches	do	
6	72	88	86	2 rains, 0.2 inch		Heavy.
7	68	94	89			Light.
8	68	92	88		Heavy	
9	69	87	86		do	
10	76	92	91		do	
11	80	95	93		do	
12	80	95	94		do	
13	81	95	90		do	
14	76	95	92		do	
15	78	94	80	1 rain, 0.2 inch	do	
16	75	92	89		do	
17	79	93	90		Light	
18	80	95	92		Heavy	
19	74	92	91	1 rain, 0.1 inch	do	
20	79	94	67	3.5 inches	do	
21	64	86	75	1 rain, 0.5 inch	do	
22	66	89	87		do	
23	75	90	90		do	
24	77	92	91		do	
25	78	90	89		do	
26	79	92	91		do	
27	74	93	92		do	
28	73	94	93		do	
29	78	97	96		do	
30	82	100	98		do	
31	76	96	78	1 rain-storm, 1.7 inches	do	
Aug. 1	76	92	80		do	
2	70	94	92		do	
3	78	95	93		do	
4	80	96	95		do	
5	78	93	92		do	
6	76	90	88		Medium	
7	79	92	91		do	
8	80	92	90		do	
9	80	93	91		do	
10	78	92	91		do	
11	79	96	94	1 rain, 1 inch	do	
12	76	90	93		Heavy	
13	83	94	88		do	
14	82	94	96	1 rain, 0.3 inch	do	
15	70	83	82	1 rain, 0.2 inch	do	
16	72	78	81	3 rains, 0.3 inch	do	
17	70	82	80		do	
18	71	85	83		do	
19	70	88	86	1 rain	do	
20	69	90	88		do	Light.
21	72	91	78	1 sprinkle	Medium	
22	66	80	79	All night, 4 inches	Rain	Light.
23	58	65	62		Heavy	
24	56	64	63		do	
25	60	61	59	All day, 1.3 inches	do	Light.
26	57	68	64		do	Medium.
27	54	82	76		do	
28	60	78	72		do	Light.
29	64	72	70		do	Heavy.
30	64	71	70	Rains, 0.7 inch	Rain	
31	68	86	78		Heavy	
Sept. 1	64	85	79		do	
2	66	87	79		do	
3	68	88	82	Many sprinkles, 0.2 inch	do	
4	72	90	87	1.2 inches	Rain	
5	70	84	78		Heavy	Light.
6	71	89	83		do	
7	70	89	84	Sprinkle	do	

Record of temperature, rainfall, dew, etc., from June 5 to October 25—Continued.

Date.	Temperature.			Rain.	Dew.	Fog.
	6 a. m.	1 p. m.	6 p. m.			
1887.						
Sept. 8	71	93	87		Heavy	
9	72	92	85		do	
10	72	92	83	1 rain, 1.1 inches	do	
11	70	88	86	2 rains, 0.3 inch	Rain	
12	74	92	88		Light	
13	75	80	67		do	
14	60	76	64		do	
15	62	80	68		Medium	
16	60	71	61	Showers, 0.4 inch	Heavy	
17	59	69	66	Rains, 0.8 inch	Rain	
18	69	80	78		Heavy	
19	70	80	72		do	
20	69	88	74		do	
21	71	83	65	Rain, 1.1 inches	do	
22	68	83	75		do	
23	51	66	58	Sprinkles	do	
24	48	65	63		do	
25	58	73	68	Rain, 1 inch	Rain	Misty.
26	62	68	63	Rain, 0.3 inch	do	Do.
27	57	66	64	Rain, 0.4 inch	do	Do.
28	60	69	68	Rain, 0.2 inch	do	Do.
29	50	64	61	Rain, 0.3 inch	do	Do.
30	56	76	72		Heavy	Heavy.
Oct. 1	60	79	75		do	
2	57	78	71	Rain, 0.1 inch	do	
3	55	77	71		do	
4	52	80	75		do	
5	61	83	76		do	
6	66	84	77		do	
7	70	76	68	1 rain, 0.6 inch	do	
8	65	75	63	Rain, 2.1 inches	Rain	
9	62	60	58	Rain, 1.3 inches	do	
10	56	64	52	Rain, 2.1 inches	do	
11	49	54	45		Heavy	
12	31	62	52		Frost	
13	38	75	60		Heavy	
14	40	71	56		do	
15	41	74	65		do	
16	49	77	67		do	
17	51	72	63		do	
18	46	62	55		do	
19	36	70	61		do	
20	45	74	65		do	
21	52	80	75		do	
22	54	81	74		do	
23	50	75	70		do	
24	42	61	58		do	
25	38	59	56		Medium	

Black Rot demands that a high temperature should be combined with sufficient and frequent humidity in order to develop most actively. It seems, although the fact has not yet been demonstrated experimentally, that an elevated hygrometric condition is not alone sufficient, but that the parasite requires precipitated water, at least for its dissemination. This hypothesis rests only upon general observations, and especially upon a remark generally made by vine-growers, to the effect that Black Rot is always less hurtful to vines that are sheltered than to those in open, exposed situations.

* * * * * * *

V.—Origin and History.

The existence of Black Rot in the interior of virgin forests upon most of the wild species of vines of the United States, from the Rocky Mount-

ains to the Atlantic and from Canada to the Gulf of Mexico, proves beyond question that the disease is of American origin. Its importation into Europe dates from 1885. * * * It may be surprising that it did not invade the French vineyards sooner. The discovery of the disease in America, however, is not very ancient, at least authentic publications which refer to it are of relatively recent date. The earlier American viticulturists, Batheam, Nicholas Longworth, and R. Buchanan, who wrote upon the Black Rot about 1848, gave only imperfect descriptions. It is common to designate all forms of decay of the grape berry or of fruit of other plants as "rot," and the authors just cited distinguished this disease only by the color of the berries attacked. We should say, however, that in speaking of rot of grapes, American viticulturists refer to Black Rot rather than mildew. We believe that the name "*Common Rot*," used in some writings, is especially applied to Black Rot. This last name is most common; that of *Dry Rot*, for the same disease, is rarely used.

It is necessary to have recourse to the *exsiccata* of the botanists who first collected the fungus in order to obtain exact information respecting its history. The study of the excellent herbarium of Harvard University, and especially of the Curtis herbarium, which Prof. W. G. Farlow kindly placed at our disposal, lending us at the same time his hearty co-operation, has enabled us to solve the very complicated and perplexing synonymy of the Black Rot fungus. It was important to know whether the numerous species described upon the fruit and leaves of different vines were really different, and whether we had yet to fear the importation of new parasites into our vineyards. Botanists have given different names, not only to the different forms of reproduction of the Black Rot fungus, but to different aspects of the disease, according to the parts of the vine or species of Ampelideæ attacked.

The oldest specimens of Black Rot are in the Curtis herbarium; they were collected in 1850 and named *Phoma uvicola* by Berkeley and Curtis. It is found, still under the same specific name, on berries collected in 1853 by Curtis, and again in 1866 by Engelmann. It is known that M. F. Von Thümen established a variety, erroneously, however, for Black Rot of the berries of *Vitis Labrusca*, naming it *Phoma uvicola* var. *Labruscæ*.

Sphæropsis uvarum of Berkeley and Curtis was collected in September, 1853, at Society Hill, S. C., and that name was changed by Saccardo to *Phoma uvarum;* it is Black Rot on the berries of *V. rotundifolia*, a species upon the fruit of which it is very rarely found.

Nemaspora ampelicida of Engelmann, was established on the spermogonia of Black Rot, but the inoculations and cultures that have been made have proven this to be one of the reproductive forms of the fungus of Black Rot.

The perithecia of *Phoma uvicola* were first observed in New Jersey by Mr. Bidwell. Prof. J. B. Ellis gave this form a short description

under the name of *Sphœria Bidwellii;* Saccardo afterwards assigned it to the genus *Physalospora*, under the name *Physalospora Bidwellii.* We found this form again, in 1887, in several localities, and it has recently been observed in France in Lot et Garonne, in Lot, and in Herault. A minute study of the perithecia, both in America and France, has caused us to classify the fungus in the genus *Læstadia.* The only specific name which now ought to be given it is *Læstadia Bidwellii.**

The scientific names for Black Rot on the leaves have been still more numerous and the consequent confusion greater. It was believed, on account of its different appearances, to represent several species having no relation to Black Rot on the fruit. This confusion has been unfortunate from a viticultural point of view, for as the Black Rot appears on the leaves much before it attacks the berries, grape-growers, in their attempts at treatment, have not troubled themselves at all about the form on the leaves, believing it to be a different disease from that on the berries and unimportant.

This error is still held by the many botanists in the United States.† We think we ought to mention that it was Professor Viala and M. Ravaz who first demonstrated the identity of the form on the leaves with that on the fruit. M. Von Thümen called "Black Rot on the leaves" of *V. rotundifolia*, *Phyllosticta viticola*, and *Phyllosticta Labruscœ* that on the leaves of *V. Labrusca;* Black Rot on the leaves of some other vines he called *Ascochyta Ellisii.*

The recent study of fresh specimens has demonstrated the identity of these forms, and also of these with the Phoma on the fruit, a fact first established by means of herbarium specimens.‡ * * *

Phoma ustulatum of Berkeley and Curtis, a species established upon the pustules observed in October, 1854, on the leaves of *Vitis æstivalis*, is also Black Rot. This name was established by these botanists on account of two refracting points in the stylospores of the Phoma form, but these points are sometimes absent in the spores of the same pycnidium.

Messrs. Ellis and Martin published *Phyllosticta ampelopsidis* for Black Rot on the leaves of *Ampelopsis quinquefolia;* they suggested, however, that this species might be only a form of *Phyllosticta Labruscœ.* The *Phoma ampelopsidis* that Saccardo mentions, found on the branches of Ampelopsis, is perhaps identical, although its larger spores make this doubtful; it is the same as *Sphœropsidis ampelopsides*, Ellis and Cooke.

Berkeley and Curtis were the first to give the name *Phyllosticta viticola* to Black Rot on the leaves of Scuppernong, but they did not publish this species, and M. Von Thümen was justified in ignoring it.

* Viala and Ravaz: "*Note sur le Black Rot*" (Progres Agricole et Viticole, June 10, 1888).

† During the past season I have made every possible effort to correct this popular error, which doubtless many have fallen into through my earlier writings.—F. L. S.

‡ Viala and L. Ravaz: "*Note sur le Black Rot*" (Progres Agricole du 10 Juin 1888, tirage a part) and "*Le Black Rot,*" 2d edition, 1888.

These authors have also applied this name to the same fungus found on *V. æstivalis*, *V. riparia*, Ampelopsis, etc. Later, Curtis published this species under the name of *Septoria viticola*, and Cooke changed it to *Sacidium viticolum*. Curtis collected it again in 1853 in Alabama upon *V. riparia;* E. Howe in 1869 upon the same species, and Ravenel upon an Ampelopsis.

All these pretended species are only the fungus of Black Rot, whose synonyms in consequence are as follows:

I. *Læstadia Bidwellii*, P. Viala and L. Ravaz! (Progres Agricole, June 10, 1888. "Note sur le Black Rot," p. 492.)
Physalospora Bidwellii, Saccardo! (Sylloge Fungorum. Pyrenomycetes, Vol. I, 1882, p. 441.)
Sphæria Bidwellii, Ellis! (North American Fungi, No. 26.)

II. *Phoma uvicola*, Berkeley and Curtis! (Grevillea, Vol. II, 1850, p. 82.)
Phoma uvicola, varietas *Labruscæ*, Von Thümen! (Die Pilze des Weinstockes, 1878, p. 16.)
Sphæropsis uvarum, Berkeley and Curtis! (North American Fungi, No. 417. Grevillea, Vol. II, 1850.)
Phoma uvarum, Saccardo! (Sylloge Fungorum, 1884, Vol. III, p. 149.)
Nemaspora ampelicida, Engelmann! (Journal of Proceedings, Trans. of the Acad. of Sci., St. Louis, 1861.)

III. *Phyllosticta labruscæ*, Von Thümen! (Die Pilze des Weinstockes, 1878, p. 189.)
Phyllosticta viticola, Berkeley and Curtis! (Unpublished, in Curtis herbarium, Cambridge, Mass.)
Phyllosticta viticola, Von Thümen ! (Die Pilze des Weinstockes, 1878, p. 188.)
Ascochyta Ellisii, Von Thümen! (Die Pilze des Weinstockes, 1878, p. 190. Viala and Ravaz: Progres agricole, 1888, tirage a part.)
Sphæria viticola, Curtis! (Curtis herbarium.)
Sacidum viticolum, Cooke. (Ravenel Fungi Americani No. 26, and Grevillea, Vol. VI, p. 136.)
Phoma ustulatum, Berkeley and Curtis! (Curtis herbarium, Cambridge, and notices of North American Fungi, No. 384. Grevillea, Vol. II, p. 82.)
Phyllosticta ampelopsidis, Ellis and Martin! (Ellis' North American Fungi, No. 1169.)
Sphæropsis ampelopsidis, C. and Ellis? (Grevillea, Plate 99, Fig 8.)
Phoma ampelopsidis, Saccardo? (Sylloge Fungorum, Vol. III, 1884, p. 79.)

VI.—Period of Attack.

The leaves appear to be more often and more severely attacked in the United States than in France. Those on the varieties of *V. labrusca* are at times entirely covered by the small spots, which have the numerous pustules arranged, especially on the upper surface, in concentric or radial series. The spots rarely become confluent; when this is the case they may cover an area measuring 4 or 5 centimeters across.

Upon the leaves of the varieties of *Vitis rotundifolia* the spots are always about a centimeter in diameter and are angular rather than circular in outline. By their uniform red color they are sharply defined upon the deep, shining green of the healthy perenchyma and are a little depressed. Further, the pustules are less numerous than on the leaves of the Labrusca, more irregularly distributed, and more frequent on the

lower surface. These are the special differences which led it to be admitted as a different species.

Black Rot attacks by preference young tender leaves, especially those at the ends of the branches; occasionally some of the latter are entirely destroyed by it. As soon as the parenchyma becomes firm, the spots, although they may be numerous, are very limited in size, and the leaves thus affected do not seem to suffer.

Black Rot always begins by attacking the leaves; an important fact, which we were the first to publish. This is constantly the case in all our vineyards when the season is wet. In years of great drought the disease, in exceptional cases, may appear on the fruit, and not show itself at all on the leaves. We observed this, for example, at Sandusky and Kelley's Island in 1887.

The leaves may be attacked at the commencement of vegetation; they are generally affected a month or three weeks before the disease shows itself on the berries. When it does appear on the latter, it is usually already very abundant on the leaves of the same vine. The exact time for the appearance of Black Rot on the leaves varies in different States, and depends upon the temperature and moisture. We have observed it near the end of May or early in June. At Neosho, Mo., in 1887, the disease appeared on the leaves about May 20 and on the fruit June 10; the first spots of mildew were observed June 12.

In Colonel Pearson's vineyard at Vineland, N. J., the initial attacks of Black Rot upon the varieties of *V. labrusca* were followed; the spots first appeared on the leaves nearest the ground, those of branches which dragged on the ground bore the greatest amount of Phyllosticta, then the young leaves of the higher branches are attacked in turn, and finally the berries.

We have observed nothing special upon branches attacked by Black Rot; it is always less frequent on these parts than on the leaves.

When the weather is warm and dews frequent, the earliest varieties are attacked when the berries are no larger than small peas; this has not yet been observed in France. The berries of late varieties, like the Æstivalis, are not actually attacked much before the period of ripening. In New Jersey, District of Columbia, and Maryland the berries may be attacked by Black Rot by the 1st of June. The young berries are less rapidly destroyed than the older and larger ones; it may be ten or fifteen days before they are completely affected.

There are generally two periods in the invasion; the first is usually mild, and coincides with the flowering of Æstivalis, the time when the berries of *Labrusca* and its hybrids are forming; during this period a third more of the crop may be destroyed. There is then about the beginning of July a period of rest. Later in this month, and especially near the beginning of August, Black Rot develops on the berries very rapidly, and may destroy the entire crop in a few days. When ripening begins the disease progresses slowly and the berries that are still healthy

are not attacked, but in warm and moist regions, those containing the parasite continue to decay up to complete maturity, at the same time presenting some special characters. They do not wither and dry up, as is generally the case, but become soft and juicy, even in Labrusca. The distended skin is as black as ink, darker than on those berries that decay before ripening. They decay without wrinkling, and the skin is studded with innumerable small pustules.*

The manifestation of the phenomena of destruction of berries attacked by Black Rot, the progressive dissemination of the disease in a vineyard, and the successive but not sudden invasion of all the grapes on the same cluster are the same in France as in the United States, and have already been described. The crop of an entire vineyard may be destroyed in eight days.

Where the seasons of growth are warm and damp (New Jersey, Maryland, the Carolinas, etc.) Anthracnose often dovelops at the same time as the Black Rot, and often upon the same berries. Sometimes Black Rot pustules may be seen on the depressed circular spots of Anthracnose which are bordered with a black ring. Sometimes again, but more rarely, Black Rot is limited to one side of a berry, and forms slightly rounded spots with pustules. Specimens having these characters were sent by Dr. Engelmann to Prof. J. E. Planchon and by him were transmitted to Max. Cornu, who from their peculiar characters was led to think that Anthracnose and Black Rot were caused by the same parasite, and that the pustules represented one form of reproduction for Anthracnose; a mistake easily made under the circumstances.†

VII.—Phenomina of Development.

The spermogonia are only formed during the first stages in the development of the rot, and we have deduced the hypothesis that on account of their lightness and probable resistance to dryness, their special rôle is that of disseminating the fungus during its period of activity. They are produced sometimes, however, under special conditions; on berries attacked by rot after they have begun to ripen and are yet juicy one finds most often only spermogonia. At Sandusky, Ohio, after a dry season we found, about August 24, many spermogonia on berries destroyed by Black Rot before the period of ripening. Aside from this exception we have never found these bodies in autumn, nor in winter on berries destroyed the season preceding.

At other times we may find the black juicy berries with all their pustules transformed into sclerotia. These sclerotia are more numerous at the end of vegetation, both upon the berries lying upon the ground and

*Berries affected as here described I have found to be attacked not by the Black Rot fungus, but by a species of Glœosporium, similar in its characters to *G. fructigeum*. —F. L. S.

†Likewise, where Brown Rot prevails, berries may be found affected at one and the same time with both Brown Rot (*Peronospora*) and Anthracnose. I observed many such on Kelly's Island, Ohio, the present season (1888).—F. L. S.

those on the vine. * * * They sometimes have the dimensions of two to five united pustules, and are composed of a membrane identical with that of the pycnidia, but with more distended cells; in the center they consist of a whitish compact tissue. Similar sclerotia have been found in June on the berries of the preceding year. In artificial cultures they produced (June 27) conidia-bearing filaments such as we have described in former publications, and which appear to have a direct connection with the interior tissues. What is the true function of these sclerotia? Do they always form conidiophores or are they transformed into perithecia? Their rôle is not yet determined.

The stylospores and spermatia are usually inclosed in separate conceptacles. Only once (in Virginia) have we observed stylospores and spermatia with their basidia intermixed in the same conceptacle.* This fact had not before been observed for Black Rot, but it has in other species of fungi of the same group.

The pycnidia are evidently the most important organs in the reproduction as well as for the perpetuation of the Black Rot. They appear soon after or at the same time with the spermogonia, and are nearly the only form present at the time of full development of the disease; their formation continues during autumn, and they persist through winter up to the following period of vegetation.

The stylospores are discharged through an opening (*ostiolum*) at the apex of the pycnidium in the form of a continuous and twisted white thread.†

In warm and moist surroundings these threads of stylospores are discharged from the pycnidia and the berries become studded with them. It is easy to cause this experimentally, either upon diseased berries of the last or the present year. It is only necessary to keep them in a moist atmosphere at 30° C., and the masses of stylospores will appear on the surface in from two to several days. The threads may be preserved entire for several weeks if kept dry. When placed in water, however, the spores separate and spread through the liquid, and there is mingled with them a large number of shining globules, which come from the material that held them together. It is necessary that the glutinous material be dissolved in drops of water in order that the spores and consequently the disease be disseminated. Precipitated water is not absolutely necessary for their germination, as we shall see, but in most cases it is needful for their dissemination. This explains why Black Rot makes but slow progress when under even partial shelter.

When the spores are discharged in threads and the weather remains dry for several days the united stylospores finally detach themselves from the apex of the pycnidia and disintegrate; three or four stylospores are carried by the wind as a fine grain of dust, and thus may

* I have observed the present season (1888) a similar case of mingling of stylospores and spermatia in the same conceptacle.—F. L. S.

† See Fig. 20, Plate IV, in Bull. 2 of this Division.

spread the disease. In this way the parasite may often pass from the leaves to the berries. If the fragments of these threads, reduced to powder, are collected and put in water the glutinous matter separates and floats in the liquid in spherical globules; the free stylospores can then germinate; but in this case the oily materials separate more slowly and it requires a little more time to effect germination. The stylospores from pycnidia preserved through winter in the fallen berries of the preceding year also germinate more slowly than those from recently formed pycnidia.

If a thread of stylospores is carefully separated and kept in a very dry place it will finally disintegrate. On adding drops of water the oily materials separate at 25° C. and the spores will germinate in the water; but if the water is removed and the spores again dried they will not germinate or change, and may be preserved a long time in this state without losing their vitality. We have been able after six months to germinate spores which were treated in this way by adding water and keeping the temperature at 30° to 35° C. This experiment proves the great vitality of stylospores and the important part they play in the preservation and propagation of the fungus.

By keeping the threads of stylospores in a damp atmosphere, but away from direct contact with water at 30° to 35° C., the threads will swell up in about five or six days without disintegrating and the stylospores on the surface will gradually begin to germinate; this proves that precipitated water is not indispensable for their development. Under the conditions first described we have never seen the spores turn dark either before or after their germination. When they are separate they are sometimes colored, especially if they are on the surface of the liquid where they are in contact with the air. Germination takes place more easily under the latter conditions; when they are submerged the spores frequently abort.

Berries turned brown by Black Rot and filled with the abundant and very characteristic mycelium, but on which no conceptacles had yet been produced, were put in a damp sterilized atmosphere at a temperature varying from 30 to 35° C. Under these conditions pycnidia developed within from five to six days. At first the mycelial filaments interlaced at certain points under the skin, forming colorless rounded masses that grew rapidly. Toward the center of these the mycelial branches become straighter, filiform, and parallel; they now merge into closely septate filaments, which are the larger the nearer they are to the outside. The septa grow thicker and more frequent, especially in the external layers which become more and more deeply colored and form a definite membrane to the pycnidium. Within this envelope the compact and colorless mycelial threads unite, and very soon their septa and points of union can not be distinguished.

In this delicate interior tissue, formed by pressure and by the union of the myce'ial threads, appear radiating hyphæ, which are the begin-

ning of the basidia. During the development of the pycnidium the basidia, which are directed towards the center of the pycnidium, swell at their free ends, forming little expansions that are slightly marked off from their supports by constriction. These are rudimentary spores, and when they have reached half their normal size they further contract below and a septum is formed at the point of support. By dichotomy the basidia occasionally form two stylospores at their ends. The spores in time acquire their normal size and shape and become densely packed in the center of the conceptacle. At the apex of the pycnidium the mycelial filaments of the external layers are less dense; as the conceptacle grows they separate at the point where the ostiolum is formed by successive distension of the tissues, and not by absorption. The opening of the ostiolum expands outwardly.

* * * * * * *

The perithecia or mature reproductive bodies of Black Rot are found fully developed only in May or early in June; they have not been found after July. This fact has been proved by our own observations and by those of Dr. E. C. Bidwell, who was the first to observe the perithecia in 1880, and whose observations have extended over several years. In his experiments Dr. Bidwell was never able to find the ascosporous form before May, and the asci had always disappeared by July. None of the grapes collected by him from the vineyard in April bore perithecia; these organs were formed only when the berries were placed in a damp chamber and kept for some time at sufficiently high temperature. The development of the perithecia is then rapid, and, as has just been observed, their duration short.

In American vineyards the grapes destroyed by Black Rot are very generally left on the vines. They fall off before or after the vintage and are scattered on the soil beneath. They are rarely covered by a late plowing. It is in these fallen grapes that the perithecia are formed. Their pustules may be recognized by the naked eye; they are more prominent and darker than those of the pycnidia and they have a more powdery or roughened appearance. They are at first imbedded in the fruit, but emerge during their growth, rupturing the dried cuticle. The dark mycelium that surrounds them is closely septate.

The general structure of the perithecia resembles that of the other conceptacles; they are walled cavities or pockets, the cells of the thick envelope being darker and a little larger than those of the pycnidia. They are perforated at the apex by a somewhat larger circular opening, having a slightly prominent border. These perithecia are usually formed at the expense of the tissues of pre-existing pycnidia; but they may also arise from the mycelium contained in the berry, or even from rudiments of pycnidia arrested in their development at the end of vegetation.

The asci spring from the bottom only of the perithecium from a stroma composed of a fine, colorless, and shining mycelium. They are as long as the perithecium is high (72 to 84 μ long and 9 to 10 μ in diameter at

the largest point). They stand parallel to each other, converging towards the ostiolum. Those at the circumference are applied to the sides of the perithecia and are strongly arched. Intermingled with them are a large number of refractive globules, but never any paraphyses. Their number varies from forty to one hundred and twenty in each perithecium (averaging eighty). In shape they are cylindrical, conical, expanded above, and abruptly tapering to a narrow base. They are filled with a finely granular, homogeneous protoplasm, from which the ascospores are differentiated. Their walls are thin and highly transparent.

When the asci are placed in water the walls soon begin to swell at the circumference, forming a sort of continuous and clearly defined penumbra, which becomes seven or eight times thicker than the original wall. A light refracting line extends around the ascus internally, and forms a small point of rupture at its obtuse point in the external portion of the membrane. The wall at first undergoes a gelification comparable to that which occurs in the membranes of certain fungi and algæ, but it does not become mucilaginous. It is, consequently, hygroscopic. At this time the sporidia are perfectly developed and still inclosed in the interior of the ascus. This later modification of the membrane in the presence of water explains the phenomenon of the discharge of the ascospores.

The sporidia, generally eight in each ascus, are colorless, subovoid and a little depressed on the sides, with thin walls and filled with finely granular protoplasm without refracting points. They vary from 12 to 14 μ in length and from 6 to 7 μ in diameter.

When a drop of dew penetrates the perithecium through the large opening at the top—and this can be accomplished artificially—the walls of the asci and the refracting material swell up, frequently rupturing the perithecium at the ostiolum through which the asci are discharged as a whole or in part. When the asci have escaped they expel the contained ascospores, as was first observed by Dr. Bidwell. Several experiments have enabled us to follow the mechanism of this expulsion, which is accomplished with considerable force. The external portion of the wall of the ascus becomes partially gelatinous and at the same time the sporidia are compressed within toward the point of rupture which has but slight resistance; the ascus is now a little arched at the apex. The external membrane absorbs water and consequently dilates, compressing the contents within; the point above finally ruptures and the sporidia are thrown out one after the other under pressure. The ascus rights itself during this phenomenon, thereby continually favoring the discharge of the ascospores. In our experiments the discharge of the sporidia occurred eight or ten hours after the berry was moistened. It can be induced in a simple manner. Take a test-tube, put in it some distilled water and a fragment of cork, upon which place the berry previously moistened by a drop of water, and then cover the

opening of the tube with a glass slide to receive the spores as they are discharged. By adding to or taking from the water in the tube the distance between the slide and the grape bearing the perithecia may be regulated. It is thus possible to ascertain the force of projection. The temperature must be kept between 20 and 30° C. The height of projection does not exceed 4 centimeters; at 2 centimeters or less the greatest number of ascospores can be obtained. These will germinate in the space of a few hours and give rise directly to a delicate mycelial tube, which is slighly curved and swollen at the end, and which soon becomes septate. The same phenomena ought to occur naturally when a drop of rain or dew falls on the similar grapes strewn over the ground when the temperature is, in May, 20 to 30° C.

The perithecia are frequently mingled with the pycnidia in such a way that they are separated only by a common membrane. There is no morphological difference between mycelial branches that surround the perithecia and those of the pycnidia in the same berry, and, besides, these perithecia are often formed directly from old pycnidia. We may conclude from this that the perithecia really belong to the Black Rot fungus; it only remains to demonstrate it experimentally, and this has recently been accomplished.* * * * * The ascospores were inoculated on healthy leaves, still on the vine, and they there reproduced the spots of Black Rot with the characteristic pustules. This experiment also indicated the time required for the incubation of the disease from infection to the beginning of the external manifestations, which is from eight to twelve days.

The asci are not always normally developed; some are simply filled with granular matter or refractive drops; others contain only rudimentary spores or a number less than eight, sometimes but two that are perfect, or even only one. When the asci have discharged their spores their walls become entirely gelatinous and rapidly disappear. The granular structure of the protoplasm of the sporidia, the structure of their membrane and the rapidity of their germination renders it evident that they have but slight resistance to external agents and that once out of the ascus they will be quickly destroyed if they do not germinate. We have seen that this is not the case with the stylospores.

The pycnidia certainly play a more important part than the perithecia even in the perpetuation of the parasite from one year to another. * * * In the spring, on berries destroyed the previous year by the Rot, the pycnidia are more abundant than the perithecia, and this is true even when single berries are considered. The spores then found in the pycnidia germinate readily. Some berries after passing the entire winter on the ground, may have no perithecia at all, only pycnidia. The pycnidia may then, as already indicated and contrary to the opinion

* P. Viala and L. Ravaz: "Note sur le Black Rot" (*Progrés Agricole et Viticole*, 1888, p. 492. *Ibid.*, "Recherches experimentales sur les maladies de la vigne" (*Comptes Rendus*, June 18, 1888, p. 1711).

advanced by some, serve to perpetuate the disease over the cold period of winter.

We have said that the fungus of Black Rot never produces paraphyses. Now the genus *Physalospora*, to which Saccardo assigned it, is essentially characterized by the presence of these organs associated with the asci. The fungus which causes Black Rot is, then, not a *Physalospora*. It approaches the genus *Phomatospora*, with which it agrees in having no paraphyses, but it differs in the form of its ascospores and by the absence from the latter of two refracting points situated at the extremities. In consequence of the characteristics of the perithecia, the asci, and the ascospores, and of the absence of paraphyses, it ought to be assigned to the genus *Læstadia* and called *Læstadia Bidwellii*. This is the only specific name that should be given it.

VIII.—Treatment.

In this country many and varied attempts have been made to combat Black Rot. The many and diverse systems of culture and pruning adopted with the view of overcoming the disease have been without effect. The powders, sulphur, plaster, ashes, lime and ashes, etc., solutions of lime, phenic acid in small quantities, salts of soda, have all been employed without success. It is true the vines were treated when the disease was already on the leaves and even on the fruit—a fact which may account for some of the failures.

It has been observed in several States, especially in Tennessee, Maryland, and New Jersey, that Black Rot either does not exist or is not as severe upon vines trained against walls that are surmounted by roofs or partial shelter. It is the same in places where vine-growers have tried to avoid Black Rot, as well as Mildew, by training the vines against a trellis topped with a board or cloth shelter. In the green-houses near Boston and in Washington the vines, even the European varieties, are exempt from Black Rot, although the neighboring vineyards in the open air were devastated by the disease. Shelter has the same indirect influence on *Læstadia Bidwellii*, as on *Peronospora viticola*—radiation of heat is prevented and consequently the deposition of dew on the vines. Drops of water are indispensable for the germination of Mildew spores; it is also necessary for the germs of Black Rot, and especially for their dissemination.

It has been several times reported to us that in the vicinity of large manufacturing cities, where great quantities of soft or bituminous coal are consumed, the thick smoke throws down large quantities of soot or coal dust. Thus at Saint Louis, Mo., the smoke is regularly driven towards the north by the winds from the Mississippi, Black Rot is rare and its attacks light in the vineyards situated in the suburbs of the city in this direction, while in the vineyards to the south of the city the loss reaches 90 per cent. The coal dust thus deposited on the vines may

hinder the penetration of the germs, carry them to the ground, or act favorably in some other way. Its influence is certain, but only interesting as a curiosity.

American viticulturists have obtained positive results by other methods which, however, would not be more practical than the preceding for our large vineyards. Many practice removing all the berries which show any signs of Black Rot, and in this way they partially overcome the disease. In Tennessee, the Carolinas, etc., they cut the branches in June, and the lower leaves are removed, so as to facilitate the circulalation of air and prevent too much moisture around the fruit. As soon as spots of Black Rot are seen on the leaves these are carefully removed, and this laborious operation is repeated as often as it is necessary. Losses are greatly diminished by this method, which is considered in those places as one of the most effectual for vineyards of any extent.

In all the States bordering the Atlantic—Maryland, New Jersey, Virginia, etc.—and in Missouri, Tennessee, the north of Texas, etc., the grape clusters are by many inclosed in common paper bags to preserve them from Black Rot. The work may be done by children, who, when the cluster is placed in the bag, draw up the mouth of the latter and fasten it around the stem with a pin. The bags cost from 75 cents to $1 a thousand, and to this price we must add the value of the labor and the cost of the pins. The grapes are inclosed when they are no larger than small peas; to be successful, it is necessary that the parasite has not already attacked them. The fruit thus inclosed ripens perfectly and acquires its normal color. The clusters that are thus protected are perfectly free from Black Rot, although the leaves on the same vine may be perforated by spots and the clusters not covered entirely destroyed by the disease. The paper bags were at first employed to protect the crop from birds, but when it was observed that they protected the berries from Black Rot their use became rapidly extended. This method is plainly impracticable for large wine vineyards, but may serve to a considerable extent in vineyards where grapes are produced for table use, and these are most numerous in the east and northeast of the United States. This method can be of service, perhaps, for grapes carefully cultivated for the table in France, but it would be absolutely impracticable in the large vineyards of that country.

For extensive vineyards it is particularly necessary to rely upon preventive treatments with poisonous agents. Some facts that we have observed lead us to hope that the salts of copper will be efficacious if used preventively. It is, in fact, impossible to think of destroying, by direct means, the conceptacles of the fungus, that are protected by very thick membranes, or the mycelium that lives in the tissues. It is necessary to prevent the first development of the germs of the parasite upon the parts of the vine, and so combat Black Rot as we combat Mildew. The germination of the stylospores, ascospores, and probably also of the spermatia, like that of the conidia of Mildew, can not take place in very dilute solutions of the salts of copper. Although rain, dew, and fogs

aid the germination of Black Rot spores in a different manner from that of the conidia of Mildew, they are not the less useful, as the spores can not develop on a dry surface. If the water when it falls can dissolve even minute quantities of salts of copper previously placed upon the leaves, the mycelium of the parasite can not develop.

At several points in Virginia, Texas, Missouri, etc., it was evident in 1887 that Black Rot had developed less on vines treated with Eau celeste than upon neighboring untreated vines. However, in the same places Black Rot had seriously injured treated vines. A careful examination of the facts will justify the statement that the vines that were partially free had been sprayed before any appearance of Black Rot on the leaves. Everywhere where applications were made after the leaves were attacked by the parasite they gave no marked result. The leaves once attacked it seemed almost impossible to prevent the disease from getting to the fruit, and this is the essential part.

We consider this as a very important observation, for we have frequently insisted upon the fact that Black Rot first attacks the leaves, and not until later, save in rare cases, does the disease communicate itself to the fruit. Now the first appearance of Black Rot on the leaves is likely to occur during the second half of May; it is necessary then that the first treatment with copper salts should be completed by May 15, the more as the period of incubation may be from eight to twelve days. We fear that the treatments undertaken the present year have been made without taking this important fact into account, and consequently we will be unable to draw any exact conclusions from them.

During the past season (1888) the value of the salts of copper in treating Black Rot, but doubtfully indicated by our experiments in 1887, has been fully demonstrated. Of the several preparations employed—Bordeaux mixture, eau celeste, ammoniacal carbonate of copper, and sulphatine—the first named* has given by far the best results.

**Copper mixture of Gironde, Bordeaux mixture.—Original formula.*—Dissolve 16 pounds of sulphate of copper in 22 gallons of water; in another vessel slake 30 pounds of lime in 6 gallons of water. When the latter mixture has cooled it is slowly poured into the copper solution, care being taken to mix the fluids thoroughly by constant stirring. It is well to have this compound prepared some days before it is required for use. It should be well stirred before applying.

Numerous modifications in the preparation of this compound have been suggested, chiefly for the purpose of reducing the amount of copper.

A solution containing the ingredients in the following proportions has been recommended for general use:

Sulphate of copper	pounds..	6
Lime	do....	6
Water	gallons..	22

The copper is dissolved in 16 gallons of water, while the lime is slaked in 6 gallons. When cool the solutions are mixed as described above.

All have been about equally efficacious in protecting the vines from Mildew (*Peronospora*), and it is difficult at this time to account for the diversity of action. In respect to the latter disease, however, the results obtained where the Bordeaux mixture has been properly applied, both in this country and in France, are so clear that we have no hesitation in saying that the Black Rot is conquered. It may now be combated successfully and by a method that is economical and perfectly practical in vineyards of the largest size.

A detailed account of experiments made the past season will be published in a special bulletin on the subject; it will suffice here to briefly summarize the experiments made by our special agent, Alex. W. Pearson, at Vineland, N. J.

The applications were made with the Eureka sprayer, May 29, June 4 and 21, July 2 and 11. The variety selected for treatment was the Concord. On the untreated vines, Rot appeared on the leaves June 8, on the fruit June 27, and by July 15 more than three-fourths of the berries had been destroyed by the disease. There were no signs of Black Rot on the vines treated with the Bordeaux mixture—6 pounds sulphate of copper, 4 pounds lime, 22 gallons of water—previous to July 20. Soon after this date these vines showed slight signs of the disease, particularly on bunches that were hidden under masses of foliage, where the spray from the pump could not easily reach them; the most exposed bunches—those most easily sprayed—remained wholly free from disease, a striking proof of the efficacy of the treatment.

By July 30 there was considerable Rot on the treated vines, evidently the result of a recent attack, as none of the diseased berries were yet blackened or shriveled. On the untreated vines one could scarcely find a bunch with more than a half dozen sound berries on it. Knowing, as we now do, that the period of incubation, or the time from the moment of infection to that when the disease becomes externally manifest, is from six to eight days, we conclude that the attack of the treated vines occurred about the 20th, or about ten days after the last application was made (July 11). In making the applications no particular care was taken to spray the clusters; the foliage was very thoroughly sprayed, however, and of course the bunches received more or less of the mixture; those clusters which were concealed by the foliage received the least, and, as already stated, these were the first to show signs of Rot. Had special care been taken to spray the bunches, and had another application been made about July 17, we believe, from what was really accomplished, that the protection would have been complete and the loss from Rot practically nothing.

It was learned from the experiments made by Colonel Pearson, who had immediate charge of and personally conducted our experimental work at Vineland, in his own vineyard, that there were two well-marked periods of attack, one about June 22, externally manifest June 27, and another July 18 or 19, becoming apparent July 26. The first period was detected through having bagged the clusters on successive rows of

vines, extending the work of bagging over a number of days. On July 30 an examination of those bagged on or before June 21 showed them to be entirely free from Rot, while those inclosed in bags after that date were more or less diseased. The vines sprayed with the Bordeaux mixture entirely escaped this first period of attack. It is interesting to note that they were sprayed June 21. Had this spraying been delayed for a couple of days, the results might have been quite different, for the spores of the fungus, then especially active, would have had time to germinate, penetrate the skin of the berry, and gotten beyond the reach of the fungicide. This is not pure speculation, but a conclusion drawn from a knowledge of the habits of the fungus.

The following experiments made by Colonel Pearson are interesting in this connection: Clusters of grapes bagged before June 21 were unbagged August 1, and left exposed for a few days and then sprayed with the Bordeaux mixture. Within a week these clusters showed a few rotten berries. These were picked off, and up to August 27 no further indication of the disease had appeared. About the middle of August a number of clusters (bagged before June 21) were unbagged and sprayed at once; others were unbagged and left without spraying. The former are yet (August 27) sound, while on the latter Rot specks are now appearing. This experiment gives additional and seemingly conclusive proof of the efficacy of the Bordeaux mixture in combating Black Rot.

In remarking upon the results of our experiments at Vineland Professor Viala says:*

* * * One will see from this that the results obtained in New Jersey, a region bordering the Atlantic, where Black Rot is developed with so great an intensity that the culture of the vine has been abandoned at several points, are to-day conclusive. M. Prillieux has announced in a recent report to the French minister of agriculture analagous effects produced by the Bordeaux mixture against Black Rot in Lot et Garonne, at Aiguillon. The experiments that we have conducted with M. L. Ravaz at Lavade (Lot) are as conclusive as those of Messrs. Prillieux and Scribner.

Thus the suppositions that we announced last year and again at the beginning of the present season, and which were based upon observations made with Mr. Scribner during June, July, and August, 1887, in New Jersey, Virginia, Missouri, and Texas, have been confirmed.

The results of the treatments are not yet perfect, but for the present they afford the assurance that Black Rot can be effectively overcome by the salts of copper, and that the same applications will serve to prevent the development of mildew and of this disease; the treatment of Black Rot will not therefore occasion any additional labors. The experiments made in France and America demonstrate that it is indispensable to begin the applications before the first appearance of the disease upon the leaves; they prove also that four or five treatments are necessary, the last to be made just before the berries begin to ripen. * * *

It appears from the reports of both Mr. Scribner and M. Prillieux that the Bordeaux mixture has given better results than the other processes. * * * The discovery of an efficacious course of treatment for Black Rot will permit, perhaps, in the future more or less remote, the development of American viticulture on a new basis.

* *Progres Agricole et Viticole* for September 2, 1888, p. 206.